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Indian Standard

SPECIFICATION FOR BALLASTS FOR HIGH PRESSURE MERCURY VAPOUR LAMPS

(First Revision)

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TO
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(*Page* 16, *clause* **9.12.3**, *line* 3) — Delete the word 'rise' before the word 'does not'.

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SPECIFICATION FOR BALLASTS FOR HIGH PRESSURE MERCURY VAPOUR LAMPS
(First Revision)

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Indian Standard
SPECIFICATION FOR BALLASTS FOR HIGH PRESSURE MERCURY VAPOUR LAMPS
(First Revision)

0. FOREWORD

0.1 This Indian Standard (First Revision) was adopted by the Indian Standards Institution on 20 August 1982, after the draft finalized by the Electric Lamps and Accessories Sectional Committee had been approved by the Electrotechnical Division Council.

0.2 This standard is intended to cover inductive type ballasts associated with high pressure mercury vapour lamps covered by various parts of IS : 9900-1981*.

0.3 In order to obtain satisfactory performance of high pressure mercury vapour (HPMV) lamps and their associated ballasts, it is necessary for certain features of their design to be properly co-ordinated. Therefore, it is essential that their specifications be written in terms of measurements made against some common reference baseline which should be reasonably permanent and reproducible.

0.3.1 Such reference baseline is fulfilled by special or selected inductive type ballasts which are called reference ballasts. These ballasts may be used for testing ordinary ballasts and for selecting reference lamps.

0.3.2 Moreover, the testing of ballasts for HPMV lamps presents particular difficulties which require a proper definition of testing methods. This testing will, in general, be made with reference lamps and, in particular, by comparing results obtained on such lamps with these ballasts and with the reference ballasts.

0.4 Because of the special characteristics of HPMV lamps, two ranges of supply voltage variation had to be considered. Whenever, safety is involved, the classical range of variation from 90 percent to 110 percent of the rated supply voltage is retained. But for certain clauses where only operational conditions are concerned, a somewhat smaller range from 92 to 106 percent of the rated value has been considered.

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*Specification for high pressure mercury vapour lamps:

Part I Requirements and test,
Part II Standard lamp data sheets,
Part III Dimensions of lamp caps,
Part IV 'Go' and 'No-Go' gauges of lamp caps.

0.5 In the relation between ballast and luminaire, a new concept has been introduced, the rated maximum operating temperature t_w of a winding which must not be exceeded in order to achieve sufficient ballast life. For the time being, this method is an alternative to the fixed temperature limits as specified in this specification (*see* **9.12** and Appendix E).

0.6 In preparing this standard, assistance has been derived from IEC Pub 262 (1969) 'Ballasts for high pressure mercury vapour lamps published by the International Electrotechnical Commission.

0.7 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

1. SCOPE

1.1 This standard covers ballasts of inductive type for use up to 250 V alternating current supply at 50 Hz, associated with high pressure mercury vapour lamps covered by various parts of IS : 9900-1981†.

1.2 Relevant clauses of this standard (for example, thermal endurance tests for windings) apply also to ballasts which form an integral part of a luminaire and which cannot be tested separately.

2. TERMINOLOGY

2.0 For the purpose of this standard, the following definitions shall apply.

2.1 Ballast — A device connected between the supply and one or more discharge lamps, which serves mainly to limit the lamp (s) current to the required value.

It may also include means for transforming the supply voltage and arrangements to correct the power factor and suppress ratio interference.

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*Rules for rounding off numerical values (*revised*).

†Specification for high pressure mercury vapour lamps:

Part I Requirements and test,
Part II Standard lamp data sheets,
Part III Dimensions of lamp caps,
Part IV 'Go' and 'No-Go' gauges of lamp caps.

2.1.1 *Independent Ballast* — A ballast consisting of one or more elements so designed that it (or they) can be mounted separately outside a lighting fitting and without an additional enclosure.

2.1.2 *Integral Ballast* — A ballast exclusively designed to be built into a lighting fitting, a box, an enclosure or the like.

2.1.3 *Drip-Proof Ballast* — A ballast intended to withstand drops of water falling in a substantially vertical direction when the ballast is placed as in normal use (for example, for use under a surface from which condensate may drip).

2.2 Reference Lamp — A lamp selected for testing ballasts which, when associated with a reference ballast under the conditions specified in Appendices C and D of this standard, has electrical characteristics which are close to the values given in Appendix A within the limits defined in Appendix C.

2.3 Reference Ballast — A special inductive ballast designed for the purpose of providing comparison standard for use in testing ballasts, and for the selection of reference lamps. It is essentially characterized by a stable voltage-to-current ratio, which is relatively uninfluenced by variations in current, temperature and magnetic surroundings, as outlined in this standard (*see* Appendix B).

2.4 Calibration Current (of a Reference Ballast) — The value of the current on which the calibration and control of the ballast are based.

NOTE — Such a current should closely approximate the nominal running current of the lamp for which the ballast is intended.

2.5 Supply Voltage — The voltage applied to the complete circuit of lamp(s) and ballast.

2.6 Working Voltage — The highest voltage, across any insulation, which may occur in open circuit conditions or during lamp's operation.

2.7 Rated Voltage — The declared voltage(s) of the supply on which the ballast is intended to be used.

2.8 Rated Maximum Operating Temperature (of a Winding) — The operating temperature of ballast winding (symbol t_w) which gives an expectancy of 10 years' continuous service at that temperature.

2.9 Rated Temperature Rise (of a Winding) — The declared temperature rise of a winding (symbol $\Delta\ t$) when tested in accordance with Appendix D under normal operating conditions at rated voltage and frequency.

2.10 Type Tests — Tests carried out to prove conformity with this standard. These are intended to prove the general quality and design of a given type of ballast.

2.11 Acceptance Tests — Tests carried out on samples taken from a lot for the purpose of acceptance of the lot.

2.12 Routine Tests — Tests carried out on all ballasts to check requirements which are likely to vary during production.

3. CONSTRUCTION

3.1 Ballasts shall be mechanically robust and shall be so designed and constructed as to minimize the effects of atmospheric moisture and of temperature changes during use.

3.1.1 An independent ballast to be installed in the base compartment of street lighting columns shall be so designed that when correctly mounted in a column:

a) any condensation falling on it shall not reach the terminals or leads,

b) there are no cavities on the exterior where moisture can collect, and

c) the terminals or loads shall be readily accessible and identifiable.

3.2 All exposed metal parts shall either be constructed of non-ferrous material or shall be adequately protected against rusting.

3.3 Fixing — Adequate robust means of fixing shall be provided.

4. TERMINALS FOR EXTERNAL WIRING

4.1 When terminals are provided, they shall comply with the following requirements:

a) Terminals shall permit the connection of conductors with cross sectional areas as follows:

Rated Wattage W	*Cross Sectional Area of Conductor* mm²
80	0·75 to 2·5
125	
250	1·5 to 4·0
400	
700	
1 000	

b) Terminals shall be fixed in such a way that they cannot work loose when the clamping screws are tightened or loosened. Terminals may be protected against loosening by two fixing screws or by a suitable locking device but covering with sealing compounds is not deemed to be sufficient protection.

c) Terminals shall be designed that the core of the conductor is held between two metal surfaces:
   1) under adequate pressure so that the conductor cannot slip out when the screw is tightened;
   2) without damage to the conductor, that is, without showing deep incisions or shearing; and
   3) without special preparation, such as soldering of the strands of the conductor, use of cable lugs, formation of eyelets, etc.

d) The terminal screws shall have an ISO metric thread or a thread comparable in pitch and mechanical strength and shall not serve to fix any other component.

e) Any terminal for external wiring shall be so located that when the connection of the conductors is correctly made:
   1) there is no risk of accidental contact between live parts of opposite polarity or between such parts and accessible metal parts; and
   2) the wires can be easily introduced and connected and the cover, if any, can be fixed without risk of damage to the wires.

4.2 When terminals other than screw type, such as pin type terminals are used for the ballast they shall be so designed that it is possible to make rigid connection with the help of suitable clamps or clips so that the clamps or clips do not slip out due to vibrations to which the lighting fittings in which such ballasts are used are subjected in normal use. The clamps should be so designed that they shall allow the wire to be connected rigidly and such that part of the clamp holds the conductor of the wire rigidly whereas the grip is made firm also by holding the insulation of the wire in the extended portion of the clamp. The connections used shall be rigid without taking recourse to other methods, such as soldering of the wire and the clamps. When such connections are used they should be adequately covered by insulation sleeving so that they are not easily accessible.

5. PROVISION FOR EARTHING

5.1 The earthing terminals, if any, shall be of a type in which the conductor is secured by means of a screw, which shall not work loose in normal use; it shall be placed near to the main terminals and shall be clearly and indelibly marked with the symbol ‘⏚ The earthing terminal shall comply with the requirements of **4.** The metal of the earthing terminal shall be such that there is no danger of corrosion resulting from contact with the earthing conductor. The screw or the other parts of the earthing terminal shall be made of non-rusting material, and the contact surfaces shall be bare metal. It shall not be possible to loosen the earthing terminal screw without the aid of a tool.

6. CREEPAGE DISTANCES AND CLEARANCES

6.1 Creepage distances and clearances shall not be less than the values given in Table 1, expressed in millimetres.

NOTE — Creepage distances are clearances shall not be less than the external surface of insulating material.

6.1.1 The contribution to the creepage distance of any groove less than 1 mm wide is limited to its width.

6.1.2 Any air-gap of less than 1 mm is ignored in computing the total air path.

6.1.3 A metallic enclosure shall have an insulating lining if, in the absence of such a lining, the creepage distance or clearance between live parts and the enclosure is smaller than the value prescribed above.

TABLE 1 CREEPAGE DISTANCES AND CLEARANCES IN AIR

(*Clause* 6.1)

Creepage distance and clearance:	
a) Between live parts of different polarity	3 (2) mm
b) Between live parts and accessible metal parts which are permanently fixed to the auxiliary, including screws or devices for fixing covers or fixing the auxiliary to its support.	4 (2) mm
Clearance:	
Between live parts and a flat supporting surface or a loose metal cover, if any, if the construction does not ensure that the values under (b) above are maintained under the most unfavourable circumstances.	6 mm

NOTE — The values within brackets apply to creepage distances and clearances completely protected against dirt. Completely sealed-off or compound-filled distances are not checked.

7. PROTECTION AGAINST ELECTRIC SHOCK AND ACCIDENTAL CONTACTS

7.1 The enclosures on independents ballasts shall have no opening giving access to live parts other than those necessary for the use and working of the auxiliary.

In addition, independent ballasts shall be so constructed and enclosed that they are sufficiently protected against accidental contact with live parts when installed as in normal use.

Lacquer or enamel is not deemed to be adequate protection or insulation for the purpose of this requirement.

7.2 Parts providing protection against accidental contact shall have adequate mechanical strength and shall not work loose in normal use. It shall not be possible to remove them without the use of tools.

Compliance with regard to the protection against accidental contact shall be checked by means of the standard test finger shown in IS : 1401-1970[*] using an electrical contact indicator. The finger shall be applied in every possible position and, if necessary, with a force of 30 N.

It is recommended that a voltage of not less than 40 V be used with an indicator lamp for the indication of electrical contact.

8. MARKING

8.1 The ballasts shall be provided with durable and legible marking as follows:

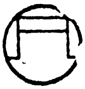
a) *Mark of Origin* — This may take the form of a trade-mark, or the manufacturer's name or the name of the responsible vendor;

b) Type designation;

c) Rated supply voltage (or voltages, if there are several), current and rated frequency;

d) Rated wattage of the lamp and, if necessary, the designation of the type or types of lamp for which the ballast is designed. If the ballast is to be used with more than one lamp, the number of lamps and their wattage shall be indicated;

e) Symbol for drip-proof, that is (if applicable);

f) Symbol for independent ballast, that is  (if applicable);

g) *Terminals*

1) When a ballast has more than two terminals or leads, other than earthing terminal, they shall be identified clearly and their rated voltage indicated. This may be implemented by numbering, and/or lettering, and/or colouring of the terminals or leads;

---

[*] Specification for accessibility test probes (*first revision*).

2) The earthing terminal (if any) shall be clearly and durably identified; and

h) Country of manufacture.

8.1.1 The following additional marking shall be added if appropriate:

a) Ballasts with a rated maximum operating temperature of a winding shall be marked with the claimed value following the symbol t_w. The values selected shall be multiples of 5.

NOTE — Preferred values are 90°C, 105°C and 120°C.

b) Ballasts with t_w marking may also be marked with the rated temperature rise of the winding following the symbol Δt.

NOTE — Preferred values are 40°C, 55°C, 70°C and 85°C.

8.1.2 The ballasts may also be marked with the Standard Mark.

8.1.3 The use of the Standard Mark is governed by the provisions of Bureau of Indian Standards Act, 1986 and the Rules and Regulations made thereunder. The details of conditions under which the licence for the use of Standard Mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.

9. TESTS

9.0 Ballasts Designed to Operate at Various Supply Voltages — If a ballast is rated for more than one value of supply voltage, it shall comply with the relevant clauses of this specification at all voltages for which it is marked. In the case of a tapped ballast, it shall be tested using the appropriate tappings.

9.1 Type Tests

9.1.1 The manufacturer shall submit to the testing authority following samples of ballasts, preferably selected at random from regular production lots, together with relevant technical data as required:

a) for ballasts without temperature marking : 5 samples

b) for ballasts with temperature marking : 12 samples (of which 7 are for the endurance test and 5 are for checking the rated temperature rise).

9.1.2 *Criteria for Approval* — The testing authority shall issue a type approval certificate, if all the ballasts are found to comply with the requirements of test. In case of failure in any test, testing authority shall call for fresh samples not exceeding twice the number of original samples and subject them to all the tests. If in repeat tests, no failure occurs, the tests shall be considered to have been satisfied.

9.1.3 Any change is design, construction, manufacturing process or material used in a ballast of approved type, shall be brought to the notice of the authority who may, at its discretion, call for fresh samples embodying these changes.

9.1.4 The following tests shall constitute type tests and shall be carried on all samples in the sequence given:

a) Visual examination (*see* **9.4**);
b) Test for creepage distances and clearances (*see* **6**);
c) Protection against accidental contacts (*see* **7**);
d) Test of terminals (*see* **9.5**);
e) Moisture resistance and insulation (*see* **9.6**);
f) Test for power and current output (*see* **9.7**);
g) Test for short-circuit current (*see* **9.8**);
h) Test for open-circuit voltage (*see* **9.9**);
j) Test for current wave-shape (*see* **9.10**);
k) Test for protection against magnetic influence (*see* **9.11**);
m) Limitation of ballast heating (*see* **9.12**);
n) Test for resistance to corrosion and brittleness (*see* **9.13**);
p) Test for mechanical strength (*see* **9.14**) ; and
q) Endurance test (*see* **9.15**).

9.2 Acceptance Tests — The following shall constitute acceptance tests to be carried out on a number of samples selected at random from each lot:

a) Visual examination (*see* **9.4**);
b) Test for short-circuit current (*see* **9.8**);
c) Insulation resistance (dry) test (*see* **9.6.3**); and
d) High voltage test (*see* **9.6.4**).

9.2.1 The sampling procedure and criteria of acceptance shall be subject to agreement between the supplier and the purchaser. In the absence of such an agreement the sampling procedure given in Appendix F may be followed.

9.3 Routine Tests — The following tests shall be carried out on all ballasts in the order given below:

a) Visual examination (*see* **9.4**) ; and
b) Insulation resistance (dry) test (*see* **9.6.3**).

9.4 Visual Examination — Visual examination of the ballast shall not reveal any damage to the ballast.

9.5 Testing of Terminals — The terminals are tested by tightening and loosening ten times on a conductor of the largest cross-sectional area required with the torque specified in Table 2. Column 2 of Table 2 applies to screws without heads which do not protrude from the hole when tightened and col 3 applies to the other screws.

TABLE 2 TORQUE TEST FOR TERMINALS

(*Clauses* 9.5 *and* D-3.6.1.2)

NOMINAL DIAMETER OF THE SCREW	TORQUE	
	Screw Without Head	Screw With Head
(1)	(2)	(3)
mm	Nm	Nm
2·5	0·2	0·4
3	0·25	0·5
3·5	0·4	0·8
4	0·7	1·2
5	0·8	2·0
6	—	2·5

9.4 Moisture Resistance and Insulation

9.6.1 The ballast shall be moisture resistant. It shall not show any appreciable damage after being subjected to the moisture treatment described in **D-3.7.1.**

9.6.2 Drip-proof ballasts shall show no visible evidence of water having entered the ballast after being subjected to the test in **D-3.7.2.**

9.6.3 Insulation shall be adequate:

a) between live parts of different polarity which can be separated;

b) between live parts and external parts including fixing screws.

The insulation resistance, measured immediately after the moisture test under the conditions specified in **D-3.7**, shall be not less than 2 MΩ.

9.6.4 Immediately after the insulation resistance test, the ballast shall, in addition, withstand a voltage test made under the conditions specified in **D-3.7.1** (b), the test voltage corresponding to the the value given below:

Working Voltage	*Test Voltage*
Up to and including 250 V	2 000 V

For the definition of working voltage *see* **2.6**. However, for the insulation between live parts and external parts, the test voltage shall be based on the rated voltage of the ballast if this voltage is higher than the working voltage.

9.6.5 *Inter-turn Insulation — (Applicable only to Ballasts without t_w or without t_w and Δ t marking)* — Ballasts shall have adequate inter-turn insulation. Compliance is checked by submitting the windings for 1 min to a voltage equal to five times the voltage occurring in normal use and steady state, at not less than five times the rated frequency; the test voltage shall not, however, exceed the value 2 500 V. During the test there shall be no short circuit between turns.

9.7 Test for Power and Current Output

9.7.1 The ballast shall limit the power and current delivered to a reference lamp to not less than 92·5 percent for the power and not more than 115 percent for the current of the corresponding values delivered to the same lamp when operated with a reference ballast. Both the reference ballast and the ballast under test shall have the same rated frequency and each shall be operated at its rated voltage (*see* **D-3.3**).

9.7.2 For any other supply voltage between 92 percent* and 106 percent* of its rated value, the power delivered by the ballast to the reference lamp shall lie between the limits of 88 percent of the power delivered to the same lamp by the reference ballast when supplied at 92 percent of its rated voltage and the limit of 109 percent of the power delivered to the lamp by the reference ballast when supplied at 106 percent of its rated voltage.

9.8 Test for Short-circuit Current — When the ballast is supplied at any voltage between 92 percent and 106 percent of its rated voltage, the short-circuit current shall not exceed the values given in Table 3, when tested as described in **D-3.4**.

TABLE 3 MAXIMUM SHORT-CIRCUIT CURRENT

(*Clause* 9.8)

BALLAST RATING (1) W	MAXIMUM SHORT-CIRCUIT CURRENT (2) A
80	1·60
125	2·30
250	4·25
400	6·85
700	11·35
1 000	15·75

9.9 Test for Open-circuit Voltage (Minimum Voltage for Stable Operation) — A ballast when operated at any voltage between 92 percent and 106 percent of its rated voltage and at rated frequency shall provide a minimum open-circuit voltage of 198 V.

NOTE — The above requirement is not applicable for 200 V of the tapped ballasts.

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*These values are under consideration.

9.10 Test for Current Wave-Shape

9.10.1 *Mains Current Wave-Shape* — The wave-shape of the current passed in the steady state by a ballast associated with a reference lamp and supplied at rated voltage and rated frequency shall be such that the value of the harmonics shall not exceed:

For 2nd harmonic	5 percent of fundamental
„ 3rd „	$25 \times \frac{\lambda}{0{\cdot}9}$ percent of fundamental
„ 5th „	5 percent of fundamental
„ 7th „	3 „ „ „
„ 9th „	2 „ „ „
„ 11th „	2 „ „ „
„ 13th „ and above	1 „ „ „

If the requirement of the second harmonic is not met, a further test, with a new lamp, shall be carried out.

NOTE 1 — In the formula of 3rd harmonic, λ is the power-factor of the complete circuit.

NOTE 2 — These values are under consideration.

9.10.2 *Lamp Operating Current Wave-Shape* — The maximum ratio of peak value to root-mean-square 9 rms value of the lamp operating current shall not exceed 1·9 at any value of supply voltage from 92 percent to 106 percent of the rated voltage of the ballasts.

9.11 Test for Protection Against Magnetic Influence — The running current of the ballast shall not be changed by more than 2 percent, when tested as described in **D-3.1**.

9.12 Limitation of Ballast Heating

9.12.1 *Limitation of Ballast Heating for Ballasts Without Temperature Marking* — When the ballast is tested in accordance with the requirements of **D-3.5.1**, the temperatures shall not exceed the appropriate values given in Table 4.

9.12.2 *Limitation of Ballast Heating for Ballasts with Marking of Rated Maximum Operating Temperature or Rated Maximum Temperature and Rated Temperature-Rise* — When the ballast is tested in accordance with the requirements of **D-3.5.2**, the temperatures shall not exceed the appropriate values in Table 4.

TABLE 4 MAXIMUM TEMPERATURE UNDER TEST CONDITIONS FOR PRINCIPLE PARTS MEASURED AT OR REFERRED TO AN AMBIENT TEMPERATURE OF 25°C

(*Clauses* 9.12.1, 9.12.2 *and* 9.12.3)

Part	Maximum Temperature in °C	
	At Rated Voltage	At 110 Percent Rated Voltage
(1)	(2)	(3)
Windings (ballast, transformer)		
If t_w is marked		
without Δt marking	80	—
with Δt marking	$\Delta t + 25$*	—
If t_w is NOT marked		
paper interleaved	—	95
not separated by paper	—	85
Test hood (on the outside) (built-in ballast)	—	85
Case of independent ballast	—	85
Terminals for external wiring	—	85
Parts made of:		
wood-filled phenolic mouldings	—	110
mineral-filled phenolic mouldings	—	145
urea mouldings	—	90
melamine mouldings	—	100
laminated, resin bonded paper	—	110
rubber	—	70
thermoplastic materials	—	—†

If materials or manufacturing methods are used other than those indicated in the table, these shall not be operated at temperatures higher than those which are proved to be permissible for these materials.

*The differences between the values of t_w and the temperature reached by the winding during the test gives an indication of the margin available for the thermal ambient immediately surrounding the ballast.

†The temperature of thermoplastic material, other than that used for the insulation of wiring, which provides protection against contact with live parts, is also determined.

The maximum temperature of the thermoplastic material is used in the determination of the resistance to heat and fire. An appropriate test is under consideration.

9.12.3 For ambient temperature higher than 25°C the maximum temperature rise will go down correspondingly so that the maximum temperature rise does not exceed the values given in Table 4.

9.12.4 After these heating tests and after cooling down, the ballast shall comply with the following conditions:

a) the ballast marking shall still be legible; and

b) the ballast shall withstand without damage a voltage test according to **9.6.4**, the test voltage, however, being reduced to the following values:

Working Voltage	*Test Voltage*
Up to and including 250 V	1 500 V

NOTE 1 — A test to detect short-circuited turns is under consideration.

NOTE 2 — A test under abnormal conditions, corresponding to a short-circuit of the lamp, is under consideration.

9.13 Test for Resistance to Corrosion and Brittleness — This test is intended to check the rust-protection offered to ferrous parts, the rusting of which may endanger the safety of the ballast.

9.13.1 All grease shall be removed from the parts to be tested by immersion in carbon tetrachloride for 10 minutes. The parts shall then be immersed for 10 minutes in a 10 percent solution of ammonium chloride in water at a temperature of 27 ± 5°C.

9.13.2 Without drying, but after shaking off drops of water, the parts shall be placed for 10 minutes at a temperature of 27 ± 5°C and at a relative humidity of 100 percent.

9.13.3 After the samples have been dried out in an oven at a temperature of 100 ± 5°C, their surfaces shall show no sign of rust.

NOTE — For small helical springs and the like, and for steel parts exposed to abrasion, a layer of grease is deemed to provide sufficient rust protection. Such parts are not subjected to the test.

9.14 Test for Mechanical Strength (for Independent Ballasts Only) — The enclosure of independent ballasts shall have sufficient mechanical strength to allow them to withstand, without damage, the mechanical hazards resulting from the test specified in **D-3.6**.

9.15 Endurance Test

9.15.1 This test shall be applied only to ballasts which are marked with the rated maximum operating temperature t_w.

9.15.2 This test may also be applied to ballasts which form an integral part of a luminaire and which cannot be tested separately, thereby enabling such integral ballasts to be marked with a t_w value.

9.15.3 The insulation and windings of ballasts shall withstand the thermal endurance test described in **D-3.8**, which is intended to control the value of the rated maximum operating temperature.

9.15.4 The thermal conditions shall be adjusted so that the objective duration of the test shall preferably be either 15 or 30 days, although the manufaturer shall be free to adopt a longer test period at a lower temperature. If no indication is given the test shall be 30 days.

9.15.5 The test shall be carried out on 7 new ballasts, which have not been subjected to proceeding tests. They shall not be used for further testing. After the test, when the ballasts have returned to room temperature, they shall satisfy the following requirements:

a) The ballast shall start and operate a lamp normally;

b) The watts loss of the ballast, when measured at nominal current, shall not have changed by more than 10 percent;

c) The insulation resistance between the winding and the case measured at approximately 500 volts dc shall not be less than 1 MΩ;

d) The ballast shall withstand a voltage test according to **9.8**, the test voltage however should be twice the working voltage.

9.15.6 The result of the test shall be considered to be satisfactory if at least 6 of the 7 ballasts satisfy these requirements. The test shall be considered to be nagative if more than 2 ballasts fail the test.

9.15.7 In the case of two failures, the test shall be repeated with 7 more ballasts and no failure of these ballasts shall be permitted.

APPENDIX A

(*Clauses* 2.2 *and* C-1.1)

LAMP TYPES AND CHARACTERISTICS

A-1. TYPES AND CHARACTERISTICS

A-1.1 The following data relates to the lamp types covered by IS : 9900 (Part II)-1981*. The electrical characteristics included in Table 5 apply to lamps operated with a reference ballast at an ambient temperature of 25 ± 5°C.

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*Specification for high pressure mercury vapour lamps: Part II standard lamp data sheets.

TABLE 5 LAMP TYPES AND CHARACTERISTICS

(*Clause* A-1)

RATED WATTAGE	RATED VOLTAGE OF REFERENCE BALLAST	ARC VOLTAGE		NOMINAL RUNNING CURRENT
		Objective	Tolerance	
(1)	(2)	(3)	(4)	(5)
W	V	V	V	A
80	220	115	± 15	0·80
125	220	125	± 15	2·15
250	220	130	± 15	3.25
400	220	135	± 15	3·25
700	220	140	± 15	5·45
1 000	220	145	± 15	7·50

NOTE — The nominal arc voltage at lamp terminals is given for the guidance of ballast makers.

APPENDIX B

(*Clause* 2.3)

REFERENCE BALLASTS

B-1. MARKING

B-1.1 The reference ballast shall be provided with durable and legible marking as follows:

a) Fixed impedance reference ballasts:
   i) the words "reference ballast";
   ii) identification of the responsible vendor and/or manufacturer;
   iii) serial number;
   iv) lamp type, rated wattage and calibration current; and
   v) rated voltage and frequency.

b) Adjustable impedance reference ballasts:
   i) the words "reference ballast";
   ii) identification of the responsible vendor and/or manufacturer;
   iii) serial number;

iv) rated voltage(s) and frequency(ies);
v) range of voltage/current ratios at rated frequency(ies);
vi) calibration current(s);
vii) maximum current per coil; and
viii) connection diagram—if appropriate.

B-2. CHARACTERISTICS

B-2.1 Genaral Design — A reference ballast is a single, or combination of self-inductive coil(s), with or without an additional resistor, designed to give the operating characteristics shown in Table 6.

TABLE 6 REFERENCE BALLASTS CHARACTERISTICS

(*Clauses* B-2.1 *and* B-2.2)

Ballast Rating	Characteristics at Rated Frequency			
	Rated Voltage	Calibration Current	Voltage/Current Ratio	Power-Factor
(1)	(2)	(3)	(4)	(5)
W	V	A	Ω (percent)	
80	220	0·80	206 ± 0·5	0·075 ± 0·005
125	220	1·15	134 ± 0·5	0·075 ± 0·005
250	220	2·13	71 ± 0·5	0·075 ± 0·005
400	220	3·25	45 ± 0·5	0·075 ± 0·005
700	220	5·40	26·7 ± 0·5	0·004 ± 0·002
1 000	220	7·50	18·5 ± 0·5	0·004 ± 0·002

B-2.2 Voltage/Current Ratio — When the calibration current is passed through the ballast, it shall give voltage/current ratio values as shown in Table 6. At any other current between 50 percent and 115 percent of the calibration current, a deviation of ± 4 percent from the impedance values in Table 6 is permissible.

B-2.3 Magnetic Shielding or Magnetic Protection — The ballast shall be protected, for example by means of a suitable steel case, against magnetic influence, in such a way that its ratio of voltage to current for the calibration current shall not be changed more than 0·2 percent when a 12·5 mm thick plate of ordinary mild steel is placed 25 mm from a face of the ballast.

Moreover, it shall be protected against mechanical damage.

B-2.4 Temperature-Rise

B-2.4.1 *Reference Ballasts for 80 W and 125 W Lamps* — When a reference ballast is operated in an ambient air temperature between 20°C and

30°C at the appropriate calibration current, the steady temperature-rise ol the winding shall not exceed 25°C as determined by the change of resistance method.

Any series or parallel resistor included in the ballast shall be in circuit during the heating period, but during the resistance measurements to determine the temperature-rise any such resistors shall be excluded.

B-2.4.2 *Reference Ballasts for 250 W to 1 000 W Lamps* — Reference ballasts for these higher wattage lamps which would comply with the thermal requirements above would necessarily be large and expensive.

B-2.4.2.1 Furthermore, the variations of the power factor, due to the temperature-rise in normal use, have little influence on the performance of the higher wattage lamps. Suitably chosen production ballasts may, therefore, be used provided they comply with the other clauses of this appendix.

APPENDIX C

(*Clauses* 2.2 *and* D-2.4.1)

REFERENCE LAMPS

C-1 CHARACTERISTICS

C-1.1 A lamp which has been aged for at least 100 hours is considered to be a reference lamp if, when operated with an appropriate reference ballast under the standard supply conditions described below and in **D-1.2**, **D-1.3** and **D-2.4**, at an ambient temperature of 25 ± 5°C under the conditions specified below, lamp wattage, voltage and current do not deviate by more than 3 percent from the values in Table 5.

C-2 OPERATION

C-2.1 Reference lamps shall be operated in an ambient temperature of 25 ± 5°C and in the position for which they are designed. Lamps which are designed to operate in any position shall be operated vertically with the cap upwards, for the purpose of this test.

C-2.1.1 Reference lamps shall operate in conjuction with the appropriate reference ballast, for at least 30 minutes immediately before being used in any of the tests detailed in this specification which require the use of such a lamp.

C-2.1.2 The characteristics of a reference lamp shall be verified immediately before and after measurements involving it are made.

C-3 WAVEFORM OF LAMP CURRENT

C-3.1 The dc component of the operating current shall not exceed 3 percent of the rms value of the current after complete stabilization.

APPENDIX D

(*Clause* 2.2)

TESTS

D-1. GENERAL CONDITIONS FOR TESTS

D-1.1 Ambient Temperature — All measurements shall be performed in a draught-free room at an ambient temperature within the range 20°C to 30°C.

D-1.2 Supply Voltage

D-1.2.1 *Supply Voltage and Frequency* — The reference ballast shall have the same nominal frequency as the ballast under test. Unless otherwise specified each ballast shall be operated at its nominal frequency and at rated supply voltage.

D-1.2.1.1 When a ballast is marked for use on a range of supply voltage or different supply voltages, the most unfavourable voltage for which it is intended shall be choosen as the rated supply voltage.

D-1.2.2 *Stability of Supply Voltage and Frequency* — The supply voltage and frequency shall be maintained constant within ± 0·5 percent. However, during the actual measurement the voltage shall be adjusted to within ± 0·2 percent of the specified rated test value.

D-1.2.3 *Supply Voltage Wave-Shape* — The total harmonic content of the supply voltage shall not exceed 3 percent, the harmonic content being defined as the root-mean-square (rms) sum of the individual harmonic components using the fundamental as 100 percent.

D-1.2.3.1 This implies that the source of supply shall have sufficient power and that the supply circuit shall have a sufficiently low impedance compared with the ballast impedance.

D-1.3 Magnetic Effects — No magnetic object shall be allowed within 25 mm of the face of the reference ballast or the ballast under test.

D-1.4 Instrument Characteristics

D-1.4.1 *Potential Circuits* — Potential circuits of instruments connected across the lamp shall not consume more than 3 percent of the nominal lamp current.

D-1.4.2 *Current Circuit* — Instrument connected in series with the lamp shall have a sufficiently low impedance such that the whole voltage drop shall not exceed 2 percent of the lamp objective arc voltage.

D-1.4.3 *rms Measurements* — Instruments shall be essentially free from errors due to wave-shape distortion.

D-2. ADDITIONAL REQUIREMENTS FOR TESTING REFERENCE BALLASTS AND SELECTING REFERENCE LAMPS

D-2.0 General — The measurements shall not be made on the reference ballast until steady temperature conditions are reached.

D-2.1 Measurements of Ratio of Voltage to Current — Figure 1 gives a typical testing circuit. If this circuit is used, no correction need be made for the current drawn by the voltmeter, provided that the resistance of the voltmeter complies with the requirements of **D-1.4.1**.

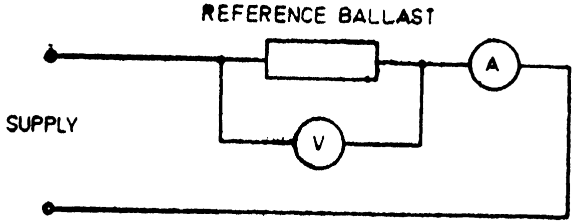


FIG. 1 RECOMMENDED CIRCUIT FOR MEASUREMENT OF VOLTAGE/CURRENT RATIO OF THE REFERENCE BALLAST

D-2.1.1 If the frequency (f) is not exactly the rated value (f_n), a correction to the measured voltage shall be applied in accordance with the following formula:

$$\text{Voltage at frequency } f_n = \text{voltage at frequency } f \times \frac{f_n}{f}.$$

D-2.2 Measurement of Power Factor — Figure 2 gives a typical circuit for the determination of the power factor. A suitable correction shall be made for instrument losses.

D-2.3 Checking of Protection Against Magnetic Influence — The steel plate referred to in **B-2.3**, shall have dimensions at least 25 mm greater than the corresponding projection of the enclosure and shall be placed in geometric symmetry to each surface as tested.

D-2.4 Selection of Reference Lamps — Figure 3 gives a recommended circuit for selecting reference lamps.

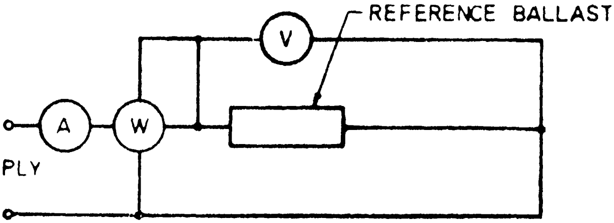


FIG. 2 RECOMMENDED CIRCUIT FOR DETERMINATION OF POWER-FACTOR OF THE REFERENCE BALLAST

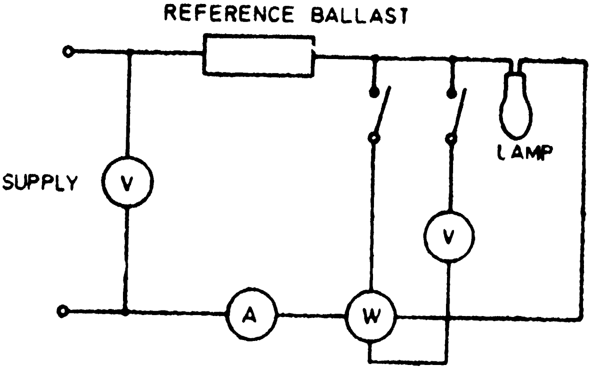


FIG. 3 RECOMMENDED CIRCUIT FOR SELECTION OF REFERENCE LAMPS

D-2.4.1 When stable burning conditions are reached, the current, voltage and power of the lamp shall be measured for compliance with Appendix C.

D-2.4.2 When measuring the voltage or power of the lamp, the potential circuit of the instrument not in use shall be open.

D-2.4.3 When measuring lamp watts, no correction shall be made for the wattmeter consumption (the common connection being made on the lamp side of the current coil).

NOTE — The reference to the absence of a correction for the consumption of the voltage circuit of the wattmeter arises from an empirical observation which shows that in most cases, at the same supply voltage, the said load compensates approximately for the reduction of the power consumption of the lamp, caused by the parallel connection of the voltage circuit of the wattmeter.

D-2.4.4 If any doubts are felt on this point, it will always be possible to evaluate the compensation error by repeating the measurements with other values of the load in parallel with the lamp. This is done by adding resistances in parallel and by reading each time the power measured by the wattmeter. It is then possible to extrapolate the results obtained in order to determine the true wattage in the absence of any parallel load.

D-3. ADDITIONAL REQUIREMENTS FOR TESTING BALLASTS OTHER THAN REFERENCE BALLAST

D-3.1 Checking of Protection Against Magnetic Influence — The test is made on the ballast in normal operation with a lamp.

D-3.1.1 A steel plate 1 mm thick and of length and breadth greater than those of the ballast under test, is successively moved close to each face of the latter. This plate is brought into contact with the face of the ballast used for fixing, but it is held at a spacing of 1 mm from the other faces. During this operation, the current absorbed by the ballast at rated voltage is measured.

D-3.2 Determination of Current Wave-Shape — The harmonic components of the supply current shall be determined by means of a selective voltmeter or wave analyser and resistor R_1 as shown in Fig. 4. The selective voltmeter or wave analayser should ensure that measurements being made on any given harmonic are not significantly affected by any other harmonic.

D-3.2.1 The peak value of the lamp current shall be determined by means of a calibrated cathode-ray oscilloscope across resistor R_2.

D-3.2.2 In either case, R_1 or R_2 shall be in accordance with the requirements of **D-1.4.2**.

D-3.2.3 When checking the influence of a variation of the supply voltage, care should be taken that this variation be made progressively.

D-3.2.4 Care shall be taken to ensure a sufficiently low impedance of the supply for the different frequencies involved.

D-3.3 Power and Current Supplied to the Lamp — The tests shall be carried out with a circuit shown in Fig. 4. Switch S_2 is in the up position and switch S_1 successively operates the lamp for the reference ballast and the ballast under test.

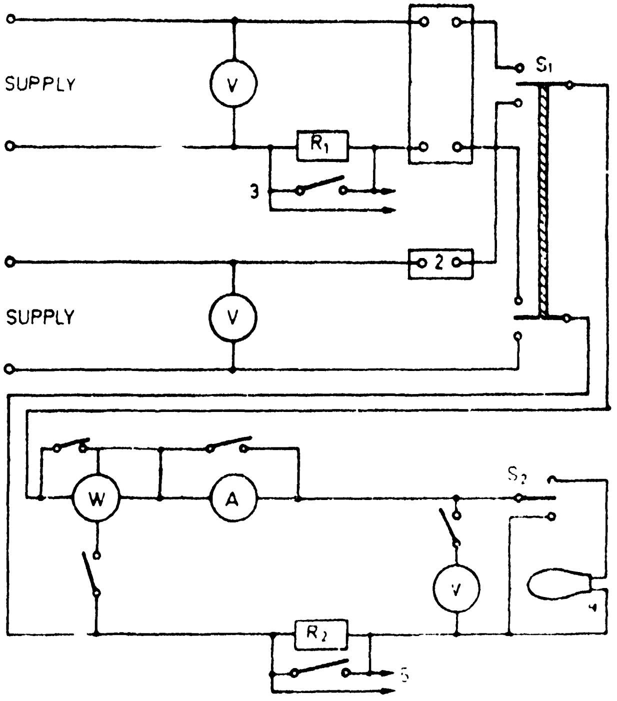
D-3.3.1 When checking the influence of a variation of the supply voltage, care should be taken that this variation is made progressively.

D-3.4 Short Circuit Test — The test circuit shown in Fig. 4 shall be used with switch S_1 in the up position and switch S_2 in the down position.

D-3.5 Temperature-Rise Test

D-3.5.1 *Ballast without Temperature Marking* — Ballasts shall be tested under normal conditions in accordance with the following details at 1·1 times the rated supply voltage and at rated frequency, with appropriate lamps, until steady temperature-rises are attained.

Lamps shall be considered appropriate if they take, under the prescribed test conditions, a current sufficiently close to the current a reference



1	ballast under test	4	reference lamp
2	reference ballast	5	cathode-ray oscilloscope
3	wave analyzer		

NOTE — When measuring lamp wattage, no correction shall be made for the wattmeter consumption.

Instruments not in use are to be short-circuited, or switched off.

A method for securing rapid switching of the lamp from one ballast to the other is under consideration.

FIG. 4 CIRCUIT FOR TESTING BALLASTS FOR HIGH-PRESSURE MERCURY VAPOUR LAMPS

lamp would take. The lamps shall be placed in such a way that the heat generated by them does not contribute to the temperature-rise of the ballast.

Temperatures are measured on windings by the resistance method and in all other cases by means of thermocouples.

D-3.5.2 *Ballast with t_w Marking* — Ballasts shall be tested under normal conditions in accordance with the following details, with appropriate lamps, until steady temperature rises are attained.

The test is carried out at rated voltage at first and when steady temperature conditions have been achieved the temperature rise(s) of the winding(s) are measured. The voltage is then raised to 1, 1 times its nominal value in order to determine the temperature rises of the other elements of the ballasts.

Other test conditions remain the same as for ballasts without temperature marking (*see* D-3.5.1).

D-3.5.3 *Built-in Ballasts* — Ballasts shall be tested in either the test hood shown in Figure 5, or the test box shown in Figure 6. The manufacturer shall declare which alternative is to be used.

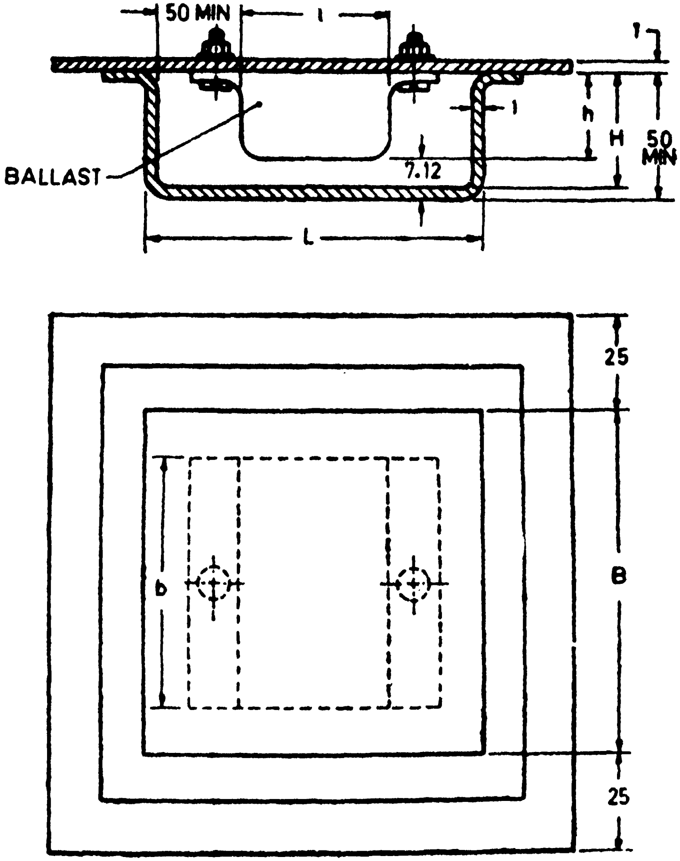
The ballasts shall be mounted in accordance with the manufacturer's instructions (if any).

In the case of the test hood and in the absence of any instructions, the ballast shall be fixed centrally and directly against the supporting surface of the hood, using all fixing holes which are coincident up to a maximum of four. During the test, the whole assembly shall be freely supported the ballast being pendant. If the test box is used, the ballast shall be mounted on a matt black wooden board, 20 mm thick, and covered with the test box. There shall be a distance of at least 10 mm between each wall of the test box and the ballast.

D-3.5.4 *Independent Ballasts* — These shall be tested without a test hood in a test corner consisting of three matt black walls at least 15 mm thick and shall be so placed as to imitate the ceiling of a room. The ballast shall be secured to the ceiling of the test corner as close as possible to the walls, and the ceiling shall extend at least 25 cm beyond the other sides of the ballast.

D-3.6 Testing of Mechanical Strength of Independent Ballasts

D-3.6.1 *Ballasts Cased in Insulation Material* — The test is made with the impact test apparatus shown in Fig. 7. The pendulum consists of a steel tube with an external diameter of 9 mm and a thickness of 0·5 mm. It is suspended in such a way that it swings only in a vertical plane. A hammer with a mass of 150 g is rigidly fixed to the lower end, with its axis 1 m below the axis of suspension. The striking element of the hammer is a hemispherical face made of hornbeam and having a radius of 10 mm.



$L = l + 100$ mm, but at least 50 mm

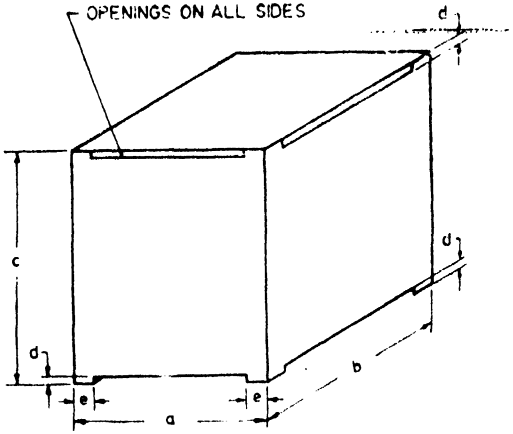
$H = h + 5$ to 10 mm, but at least 50 mm

$B = b + 10$ to 20 mm, but at least 80 mm

NOTE — The hood consists of 1 mm thick iron sheet painted white, inside and outside.

All dimensions in millimetres.

FIG. 5 HOOD FOR HEATING TEST



DIMENSIONS (mm)

a	b	c	d	e
130	130	150	—	—
250	250	300	8	25
300	450	500	12	35

NOTE — The outer housing consists of 1 mm thick galvanized sheet, painted white, inside and outside.

FIG. 6 TEST BOX FOR HEATING TEST

D-3.6.1.1 The support for the sample is such that:

a) the sample can be so placed that the point of impact lies in a vertical plane through the suspension axis of the pendulum;

b) the sample can be turned round an axis perpendicular to the support;

c) the sample can be turned round a vertical axis; and

d) the sample can be moved horizontally and vertically.

C-3.6.1.2 The sample is mounted on the support as in normal use, cable entries are left open, fixing screws of covers are tightened with two-thirds of the torque indicated in Table 2.

D-3.6.1.3 The sample is so placed that the point of impact lies in a vertical plane through the axis of the pendulum.

D-3.6.1.4 The hammer falls from a height of 15 cm, measured vertically between the point of impact on sample and the nose of hammer at the point of release.

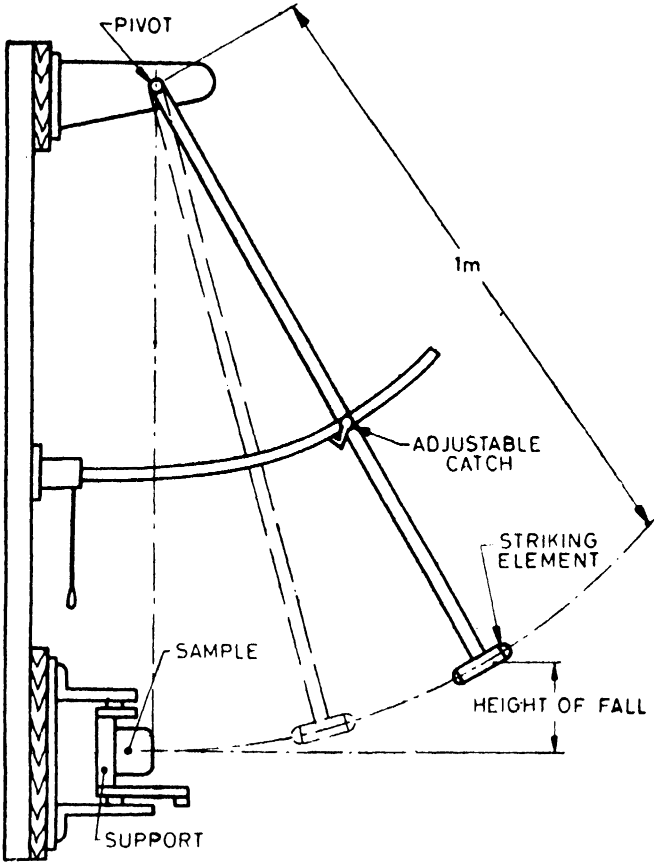


FIG. 7 IMPACT TEST APPARATUS

D-3.6.1.5 Ten blows are applied to points evenly distributed over the sample.

After the test, the sample shall show no cracks or other damage within the meaning of this specification.

Cracks will only be considered as faults if they are visible to the naked eye. Provided that the protection against accidental contact is not affected, small pieces may be detached without causing rejection.

D-3.6.2 *Ballasts Cased in Metal* — Auxiliaries with metal enclosures are first subjected to the test of **D-3.6.1**, the hammer falling from a height of 27 cm.

In addition, they are then subjected to the following test:

A test finger (*see* IS : 1401-1970*), but not flexible, is pressed perpendicularly with a force of 50 N on different points of the enclosure.

After these tests, the samples shall no damage within the meaning of the specification.

Damage to paint and small dents which do not influence creepage distances or clearances are neglected.

D-3.7 Moisture Resistance and Insulation

D-3.7.1 The ballast under test shall be brought to a temperature within 1°C of the ambient temperature, which shall be between 35°C and 40°C. It shall then be placed in a moisture treatment box, containing air with a relative humidity of 95 ± 2 percent and left there for 48 hours, ensuring that the temperature variation does not exceed ± 5°C.

Cable entries, if any, shall be left open. If knock-outs are provided one of them shall be removed. The ballast shall be mounted in accordance with the manufacturer's instructions (if any).

D-3.7.1.1 Before the insulation test, visible drops of water shall be removed by means of blotting paper.

The insulation resistance shall be measured with a dc voltage of apporoximately 500 V, 1 min after application of the voltage. Ballasts having an insulating cover or envelope shall be wrapped with tinfoil. The insulation resistance is then measured.

i) between live parts of different polarity which can be separated;

ii) between live parts and all external metal parts including the tinfoil wrapping of external parts of insulating material.

The voltage test is made with an appropriate ac voltage (*see* **9.8**) at rated frequency for 1 min, between the same parts as specified above. Initially, not more than half the specified voltage is applied, the voltage is then raised rapidly to the prescribed value.

No flashover or breakdown shall occur during the test.

NOTE — Glow discharge produced during the test but without a drop in voltage is neglected.

D-3.7.2 *Drip-proof test* — Drip-proof ballasts shall be subjected for 5 min to artificial rain falling vertically from a height of 2 m from above the top of the ballast and at a rate of approximately 3 mm per minute.

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*Specification for accessibility tests probes (*first revision*).

D-3.8 Thermal Endurance Test for Windings — The test shall be carried out in an appropriate oven (Fig. 8 shows a suggested design of oven).

According to practical experience, a uniform and stable temperature can be achieved in two ways:

a) by an oven which is not provided with a good thermal insulation; and

b) by a very good thermal insulation of the ballasts so that they themselves provided (most of) the heat needed for the test.

The description underneath refers to the "oven method":

a) when the "self-heating method", and

b) is used, the current through the ballast shall be kept constant.

The ballast shall function electrically in a manner similar to that in normal use and in the case of capacitors or other components which should not be subjected to the test, these shall be disconnected and reconnected again in circuit, but outside the oven. Other components which do not influence the operating conditions of the windings may be removed.

In the case of ballasts which form an integral part of a luminaire, it may be necessary to use special high temperature luminaire wiring, and any part of the luminaire structure which is not essential to the test may be removed in order to keep the physical size of the integrated ballast/luminaire part within reasonable limits.

NOTE — In the cases when it is necessary to disconnect capacitors or other components which should not be subjected to the test it is recommended that the manufacturer supplies special ballast with these parts removed and any necessary additional connections brought out from the ballast.

In general, to obtain normal operating conditions, the ballast shall be tested with the appropriate lamps, but for certain inductive type ballasts the lamps may be replaced by equivalent resistances adjusted to maintain the mean value of current through the ballast. The lamps or the equivalent resistances shall be mounted outside the oven. The ballast shall be earthed.

D-3.8.2 Before the test, the following shall be measured and checked;

a) normal starting and operation of the lamp by the ballast;

b) the resistance of each winding at the ambient temperature; and

c) watts loss of the windings at nominal current.

The batch of 7 ballasts shall then be placed in the oven and the rated voltage applied to the circuits.

D-3.8.3 The oven thermostats are then adjusted in such a way that the internal temperature of the oven attains a value such that the temperature of hottest winding in the ballast is approximately equal to the objective value given in Table 7 below:

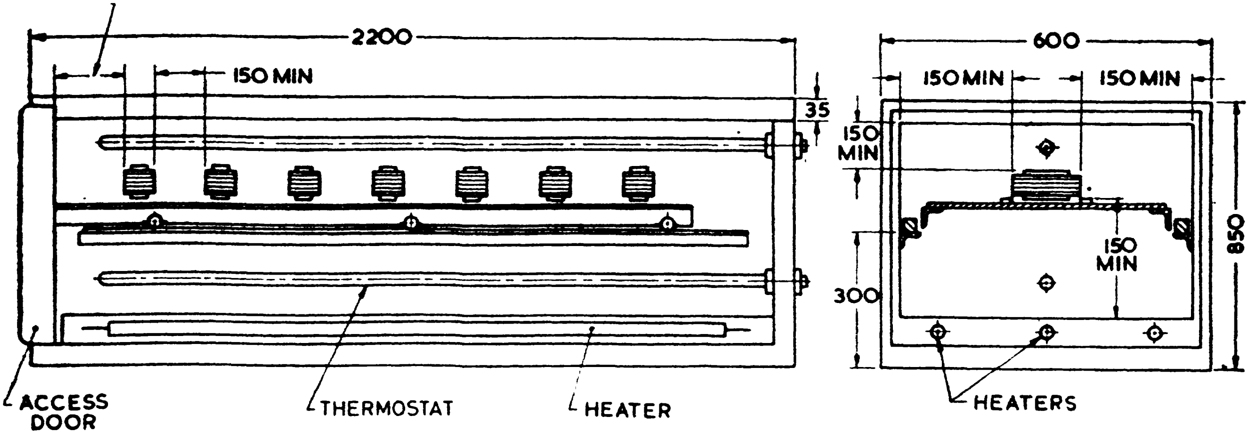

FIG. 8 DIMENSIONS AND LAYOUT OF A TYPICAL HEATING CABINET FOR THERMAL ENDURANCE TEST

TABLE 7 OBJECTIVE TEST TEMPERATURE

(*Clause* D-3.8.3)

Maximum Rated Operating Temperature t_w °C	Objective Test Temperature in °C for Test Period of	
	15 days	30 days
90	176	163
105	200	185
120	223	207

Note 1 — If t_w values of 125°C and 130°C are required, then, provisionally, the constant 4 500 may be used in the formula. A change in this constant for t_w values greater than 120°C is under consideration (*see* Appendix E).

Note 2 — Values of t_w greater than 130°C and the constant(s) required are under consideration (*see* Appendix E).

D-3.8.4 After 4 h, the actual temperature of winding is determined by the "increase in resistance" method and, if necessary, the oven thermostats are readjusted as close as possible to the objective test temperature.

D-3.8.5 The winding temperatures are measured against after 24 hours and the final test period for any ballast is determined from the curve given in Fig 8. The permissible difference between the actual temperature of the hottest winding of any of the ballasts under test and the objective value shall be such that the final test period is not less than 10 days for an objective life of 15 days, not more than 60 days for an objective life of 30 days.

Note — No attempt should be made to hold constant the winding temperature after the measurement at 24 h. Only the ambient air temperature should be held constant by the thermostatic control.

Thereafter, a daily reading of the air temperature in the oven shall be taken to ensure that the thermostats are maintaining the correct value to within ± 2°C.

D-3.8.6 The test period for each ballast commences from the time the ballast is connected to the supply. At the end of its test, the relevant ballast is disconnected from the supply but it is not removed from the oven until the test on the other 6 ballasts have been completed.

The objective test temperatures given in Table 7 should correspond to a working life of 10 years continuously at temperature t_w.

They are calculated on the basis of the following formula:

$$\text{Log}\, L = \log Lo + 4\,500 \left(\frac{1}{T} - \frac{1}{T_w} \right)$$

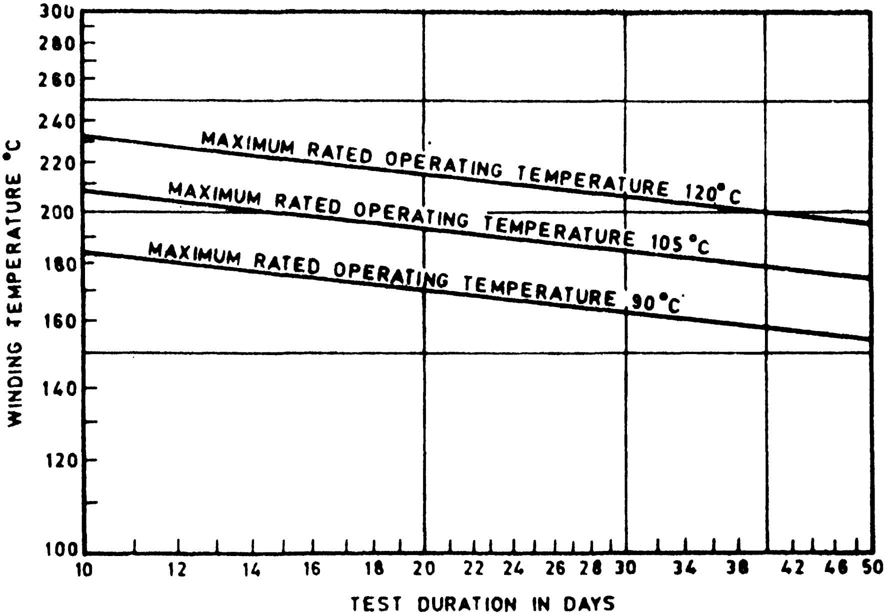

FIG. 9 RELATION BETWEEN WINDING TEMPERATURE AND TEST DURATION

where:

L = objective test life in days

Lo = 3 652 days (10 years)

T = theoretical test temperature in K

Tw = rated maximum operating temperature in K

The constant 4 500 has been established empirically.

APPENDIX E

(*Clauses* 0.5, D-3.8.3 *and* Table 7)

BALLAST ENDURANCE TESTING

E-1. INTRODUCTION

E-1.1 The intention of this appendix is to stimulate member countries further to investigate ballast endurance testing, based on the t_w concept, and in particular to determine the constant(s) required, in the formula relating test life and actual ballast life, for t_w values greater than 120°C.

E-2. THEORETICAL BASIS

E-2.1 The present life versus temperature relationship for insulation system of ballasts is based on the following equation:

$$L = Ke^{\frac{D}{T}}$$

where:

L = life of the insulation system in days
T = temperature of the insulation in K
D = constant which is related to the insulation material
e = base of naparian logs — 2·718
K = equation constant which depends upon the units shown.

If an insulation system is tested at two different temperatures, it will give two different lives and then two equations can be written thus:

$$L = Ke^{\frac{D}{T}}$$

$$Lo = Ke\,\frac{D}{Tw}$$

where:

L = theoretical test life in days
Lo = 3 652 days (10 years)
T = theoretical test temperature in K
Tw = rated maximum operating temperature in K

then:

$$\frac{L}{Lo} = \frac{Ke^{\frac{D}{T}}}{Ke^{\frac{D}{Tw}}}$$

and taking log 10 of both sides:

$$L \log L - \log Lo = \frac{D}{T} \log e - \frac{D}{Tw} \log e$$

Since log e is also a constant, it can be included with D (the material constant) to give a new constant $P = D \log e$

and therefore: $$\log L = \log Lo + P\left(\frac{1}{T} - \frac{1}{Tw}\right)$$

The value of the constant P which has been adopted empirically is 4 500 for t_w temperatures up to and including 120°C.

E-3. BASIC MATERIAL TESTS

E-3.1 The temperature classifications of enamelled winding wires are frequently based on IS : 5825-1970*, and A.I.E.E. 57 twisted pair tests and curves which are published by wire manufacturers. The standard wire diameter for this test is 0·8 mm. Samples prepared in a specified manner are tested in an oven at various temperatures for the time taken for breakdown between wires. The test voltage is 1 000 V. The inverse absolute temperature is plotted against time on a logarithmic scale and the curve is extrapolated to 20 000 h. The corresponding temperature is taken as the thermal classification of the enamelled wire.

The data produced by various wire manufacturers do not agree very closely, but the slopes (constant P) of the curves for insulation materials classified in IS : 1271-1958. Classification of Materials for the Insulation of Electrical Machinery and Apparatus in Relation to their Thermal Stability in Service (for example Class A, etc.), correspond fairly well with these given for t_w in IEC ballast specifications. However, the classification according to twisted pair tests is based upon a 20 000 h life (2·4 years) and if, for example, the line for a typical Class E (120°C) insulation is extrapolated from 20 000 h to 87 000 h (10 years), the temperature is 98°C, that is lower than Class A.

Moreover, in an endurance test on twisted pairs, the wire is at a uniform temperature, whereas where a wound component is tested there is a hot spot in the winding which may have a temperature of 10°C higher than the average temperature upon which the test is based.

These A.I.E.E. twisted wire tests show different constants depending on the insulation used. These constants are not necessarily the same when the wires are used in a ballast.

E-4. MATERIALS IN BALLASTS

E-4.1 The basic material tests show that different constants are required for different insulation classes. When using these same materials in ballasts, it is to be expected that other constants will apply. The ballast constants will take into account not only the winding wire characteristics but also the characteristics of other materials included, the ballast construction and the different testing methods.

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*Guide for evaluation of thermal endurance of enamelled wires.

From the previous considerations and the results of the limited number of tests which have been carried out, it would appear that to pass a t_w = 120°C test, a ballast must be wound with a wire rated 155°C, that is a polyester enamelled wire. Similarly, a t_w = 155°C ballast would need a 180°C wire (polyester-imide).

Accordingly, the curves shown in Figure 8, have slopes (constants *P*) corresponding to those of insulating enamels two classes higher, by the twisted pair test, than the t_w marked temperatures of 130°C and 155°C.

It is believed that the t_w test temperatures derived from these curves are sufficiently conservative to allow for differences in materials and construction of ballasts.

They are submitted for trial. Much more testing is necessary and when more results are available the curves may need to be adjusted.

E-5. ENDURANCE TESTING PERIOD

E-5.1 At the present time a 15 day or 30 day testing period is permitted, at the manufacturer's choice, and is related to the constant of 4 500. If this constant changes to a higher value, the testing sensitivity and accuracy is reduced and a longer testing time is necessary. It may be necessary, therefore in the light of future experience, to consider abandoning the 15 day testing period and to introduce another alternative period longer than 30 days.

APPENDIX F

(*Clause* 9.2.1)

SAMPLING PROCEDURE FOR ACCEPTANCE PURPOSE

F-1. LOT

F-1.1 In any consignment, all the ballasts of the same make, model and type and manufactured under similar condition of production shall be grouped together to constitute a lot.

F.2 SELECTION OF SAMPLES

F-2.1 The number of ballasts to be selected at random from a lot shall depend on the size of the lot and shall correspond to the value specified in col 2 of Table 8 for the various sizes referred to in col 1. All the ballasts shall be subjected to the acceptance tests specified in **9.2**.

F-2.1.1 If required for repeat tests (*see* **F-3.2**) additional number of samples of ballasts shall also be selected at random as given in col 3 of Table 8.

TABLE 8 SAMPLING PLAN

(*Clauses* F-2.1, F-2.1.1 *and* F-3.1)

LOT SIZE	N_1	N_2	(N_1+N_2)	C_1	C_2
1	(2)	(3)	(4)	(5)	(6)
51-100	10	20	30	0	3
101-200	13	26	39	0	5
201-300	20	40	60	1	5
301-500	25	50	75	1	6
501-800	35	70	105	2	7
801-1 300	50	100	150	3	10
1 301 and above	75	150	225	5	12

NOTE — The plan recommended in this table assures that lots with defectives 4 percent or less would be accepted most of the time, and lots with defectives 25 percent and above would be rejected most of the time. The exact consumer's risk depends on the lot size and it would be minimum when the lot size is maximum.

F-3 CRITERION FOR CONFORMITY

F-3.1 The lot shall be considered as conforming to the requirements of acceptance tests if the number of failures in the first sample is less than or equal to acceptance number C_1 given in col 5 of Table 8. If the number of failures is greater than or equal to the rejection number C_2 as given in col 6 of Table 8, the lot shall be considered as not conforming to the requirements of the acceptance test.

F-3.2 If the number of failures is between C_1 and C_2 a further sample of N_2 ballasts shall be selected and subjected to the acceptance tests. If the number of failures in the two samples combined is less than C_2 the lot shall be considered as conforming to the requirements of acceptance tests or otherwise not.

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